# When economists and ecologists meet on Ecological Economics: two science paths around two interdisciplinary concepts

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**Abstract.** Ecological economics essentially grew out of economists working in the environmental field and growing dissatisfied with the way that standard economics saw interactions between nature and societies and ecologists anxious to take human activities (including economic) into account in a much more direct way, within the dynamic of the ecosystems on which they depend. This clearly inscribed the new field of ecological economics within an interdisciplinary and even transdisciplinary perspective. In order to try to provide some thoughts on the evolution of this trend and the relationship between economists and ecologists, we have chosen to focus on two items[1] that are undoubtedly among the achievements of ecological economics, although their mobilization is far from uniform among the authors who make use of them: coevolution and ecosystem services. In order to do so, the itinerary of two authors recognized in the field of ecological economics will be examined: Richard B. Norgaard, whose work on the coevolutionary paradigm (Norgaard, 1994) is recognized as one of the foundations of ecological economics (Munda, 1997); Robert Costanza, who initiated work on the monetary valuation of ecosystem services

[1] For the moment, we would like to use the generic term for the subject. We shall see later that these subjects may be alternatively (and often also simultaneously) used as metaphors, concepts, and instruments of public policy.

(Costanza et al., 1997) that is a marker in the field of ecological economics. What unites these two authors is a manifest interest in the work coming out of systems analysis in the 1970s - as we shall see, that interest ultimately led to fairly contrasting visions of the field of ecological economics.

## 1. Introduction

Nearly thirty years after the creation of ecological economics, it seems fitting to review its achievements conceptually and also in view of the objectives that were assigned to it at its creation. Ecological economics essentially grew out of economists working in the environmental field and growing dissatisfied with the way that standard economics saw interactions between nature and societies and ecologists anxious to take human activities (including economic) into account in a much more direct way, within the dynamic of the ecosystems on which they depend. This clearly inscribed the new field of ecological economics within an interdisciplinary and even transdisciplinary perspective, as is emphasized by the subtitle of the journal *Ecological Economics*, created in 1989. Today, what remains of the original aspirations? How has the "encounter" between economy and ecology unfolded, and what has this encounter led to? Answering this question exhaustively would no doubt require telling the story of the individual paths of thousands of researchers involved in collaborative research operations, which would no doubt highlight the uniqueness of each of these paths and would be difficult to reduce to broad typologies. In order to try to provide some thoughts on the evolution of this trend and the relationship between economists and ecologists, we have chosen to focus on two items[2] that are undoubtedly among the achievements of ecological economics, although their mobilization is far from uniform among the authors who make use of them: coevolution and ecosystem services. The literature mobilizing these two concepts within ecological economics is quite extensive, which is why we have chosen to study each of these subjects through the path of two authors who were among those at the beginning of the ecological economics trend and whose names are generally associated with both of these subjects: Richard B. Norgaard, whose work on the coevolutionary paradigm (Norgaard, 1994) is recognized as one of the foundations of ecological economics (Munda, 1997); Robert Costanza, who initiated work on the monetary valuation of ecosystem services (Costanza et al., 1997) that is a marker in the field of ecological economics. Moreover, exploring the encounter between economists and ecologists through these two figures seems relevant to us, since the first made the journey in one direction



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(from economy to ecology), while the other kind of took the opposite path (from ecology to economy). What unites these two authors is a manifest interest in the work coming out of systems analysis in the 1970s - as we shall see, that interest ultimately led to fairly contrasting visions of the field of ecological economics.

## 2. Richard B. Norgaard and the concept of coevolution

Richard B. Norgaard, currently Professor Emeritus in Resource and Energy Economics at the University of California, Berkeley, is a founding member of the International Society for Ecological Economics – a Society he also chaired from 1998 to 2001. A trained economist (B.A. in Economics from the University of California, Berkeley, an M.S. in Agricultural Economics from Oregon State University, and a Ph.D. in economics from the University of Chicago in 1971), he nevertheless felt early on the need for a dialogue on economy and ecology that would have an interdisciplinary perspective. This commitment was a legacy of complex thought and systems analysis, two fields that, during a large part of his career, he applied to the notion of coevolution. Before discussing how this author has mobilized the notion of coevolution, let us look at his original methodological and epistemological positioning, which led him to consider an interdisciplinary dialogue between economists and ecologists.

### *2.1.A plea for methodological pluralism*

Richard B. Norgaard is known, within the field of ecological economics, to have emphasized the need to adopt methodological pluralism (Norgaard, 1989) - this position is also often recognized as one of the foundations this trend (Gowdy and Erickson, 2003; Lo, 2014), even if some authors, like Clive Spash (2012), believe that methodological pluralism harms ecological economics more than it serves it.

Norgaard (2003) recognizes first of all that the disciplines of economics and ecology are far from unified. Each is criss-crossed by various trends that use very different languages, and communication between these different trends is often complicated and would be so even if they were to use similar terminology. In fact, behind an apparent disciplinary homogeneity, in reality, a struggle for values and world views, which are difficult to reconcile, is being played out. But, according to Norgaard (1994: 96), "*[m]ost people, including scientists, still believe that our multiple ways of understanding different aspects of ecosystems can be merged into one coherent view*". In such a context, the idea of achieving a unified vision of the relationship between economy and ecology, in a new field - ecological economics - may seem illusory. Ecological economics can therefore be marked out as a field of mutual understanding of different visions and values that run through these two disciplines. This new field of experimentation can thus be defined as "*an effort to hasten a particular merger by pushing ecological understanding towards economics, and economic understanding towards ecology*" (Norgaard, 2003:1). Thus, Norgaard considers coevolution to be a concept that allows us to think about the relationship between economy and ecology - that is, a border concept.

### 2.2. Is the coevolutionary paradigm the foundation of ecological economics?

The term coevolution was introduced in the early 1960s in the field of biology, following an article by Paul Ehrlich and Peter Raven entitled "Butterflies and Plants: A Study in Coevolution" (Ehrlich, Raven, 1964). The concept of coevolution was mobilized to describe a genetic change in a species in response to the evolution of another species. Thus, strictly speaking, coevolution indicates the evolution of two populations that have internal diversity and interact so that they influence the selection environment of each other, so that their evolutionary trajectories are coupled (van den Bergh, 2007). Gradually, this concept has been expanded to denote different forms of coevolutionary interactions between species or between genes. More recently, the concept has been applied to a group of types of interaction between genetic changes and cultural changes within the human species, in particular. The metaphorical use of coevolution has enabled its use later in fields as diverse as technical change and socioeconomic issues (Rammel *et al.*, 2007).

In the late 1970s, Richard B. Norgaard looked at coevolution as a means of understanding the relationships that develop between natural systems and social systems, particularly through the dynamics of environmental and social change. Initially, Norgaard mobilized this concept following a mission on the management of the Amazon area which he undertook in the 1970s with the Brazilian government (Norgaard, 1981). Strongly influenced by systems analysis (through the work of Boulding, in particular), he borrowed the term coevolution from Ehrlich and Raven (1964), although curiously, he does not refer to their article in his early work[3]. He takes up this notion for his own purposes, applying it to social systems and ecosystems. He illustrates, through the agricultural issue, that far from evolving independently of each other, ecosystems and human societies co-operate, that is, their evolutionary paths

[3] Norgaard nevertheless cites Paul Ehrlich in the acknowledgments of his 1981 article, and Ehrlich figures, through another reference, in the final bibliography of this article.

influence each other. In fact, just as in the field of biology, there is a constant interaction between organisms and their environment (the organisms are not just the result, but they are also the cause of their own environment), there is a constant interaction between ecosystems and societies. More precisely, Norgaard (1994:40-41) indicates : " ... *social and environmental systems coevolve such that environmental systems reflect the characteristics of social systems – their knowledge, values, social organization, and technologies – while social systems reflect the characteristics of environmental systems – their mix of species, rates of productivity, spatial and temporal variation, and resilience. The coevolutionary description of development explains why, and to some extent how, everything is related to everything else*". To the extent that evolution, in the Darwinian sense of the word, engages the three processes of variation, inheritance, and selection (Kallis, Norgaard, 2010), these three processes are also found in the idea of coevolution of environmental and social systems. As stressed by Norgaard (1994: 41): "*People survive to a large extent as members of groups. Group success depends on culture: the system of values, beliefs, artifacts, and art forms which sustain social organisation and rationalise action. Values and beliefs which fit the ecosystem survive and multiply; less fit ones eventually disappear. And thus cultural traits are selected much like genetic traits. At the same time, cultural values and beliefs influence how people interact with their ecosystem and apply selective pressure on species. Not only have people and their environment coevolved, but social systems and environmental systems have coevolved*". Let us recall that two systems coevolve when at least one of the systems is evolving and influences the other system (Norgaard, 1985).

It was by analysing the set of conventions governing the idea of development, from a Western perspective, that the idea of coevolution was born (Norgaard and Kallis, 2011). According to Norgaard, five conventions guide development models in Western thought: atomicism (also called reductionism, but in a pejorative sense), mechanism (a vision of a clock-like world where it is possible to accurately predict the paths of certain objects), universalism (the idea that everything can be explained, at any time and any place, with the use of a limited number of scientific laws), objectivism (which leads to analysis of phenomena by keeping them at arm's length, as if the analyst had no control over them), and monism (the idea that our different ways of seeing the world can ultimately be synthesized in a consistent manner). With this analysis grid in mind, it became possible for R.B. Norgaard to reread the development of the Brazilian Amazon, shaped by these influences and by the idea of progress that underlies it, and to propose, *conversely*, a radically different vision of development that can be summed up in the idea of coevolutionary development. Coevolutionary development thus appears as a paradigmatic vision of the relationship between human societies and ecosystems. The coevolutionary development process is therefore built from the interaction between the five dimensions that Norgaard (1994) identifies as important: values, technology, environment, organization, and knowledge. These interactions are by nature dynamic and non-deterministic - thus unpredictable. Moreover, Norgaard attaches particular importance to distinguishing this approach from the A - M (Atomistic-Mechanistic) vision that he associates with the development approach in the field of environmental economics and natural resources (Norgaard, 1985).

The concept of coevolution was recognized very early on as a key concept in defining the scope of the field of ecological economics (Gowdy, 1994; Spash, 1999), and even as a unifying theme, a paradigm (Munda, 1997). According to Spash (1999:425) : "*Evolutionary dynamics are an important aspect of ecological economics which emphasise that economic and environmental systems are interacting and changing, often unpredictably, rather than static, and this implies analysing non-deterministic processes rather than optimal paths to static equilibria. However, the particular interpretation via the coevolutionary paradigm remains a topic for open debate within ecological economics*".

However, it is important to acknowledge that with the exception of a limited number of authors (John Gowdy, Giorgos Kallis, Richard Norgaard, Christian Rammel), coevolution has not really been a distinguishing feature recognized as a unifying idea by proponents of ecological economics. Recent work (Rammel *et al.*, 2007; Kallis and Norgaard, 2010), however, offers some interesting paths allowing us to take stock and sketch out future developments for a research program based on the notion of coevolution in the field of ecological economics.

It is difficult to describe coevolution as a subject, in light of the various ways in which the term is used. At different times, Norgaard himself uses it to talk about the coevolution and the coevolutionary development of a model (1985), a paradigm (1984), a concept (1985), and even a metaphor.

When Norgaard addresses coevolutionary development as a paradigm, he generally opposes the mechanistic-atomistic Newtonian paradigm that is often used in the field of environmental economics and natural resources (Norgaard, 1985).

The status of coevolution in the work of Norgaard must be understood in light of the interest that he had in metaphors in the scientific field. Biological metaphors and analogies have abounded in the area of economic analysis since at least the eighteenth century[4]. Consequently, it is not surprising that ecological economy has grown by espousing this view, from the '*cowboy economy*' of Boulding (1966), by way of the idea of critical natural capital (Chiesura, de Groot, 2003), to the idea of ecosystem service (Norgaard, 2010). Throughout his career, Norgaard has developed a number of reflections on the metaphorical use of concepts in the environmental field, whether about carrying capacity (Norgaard, 1995), ecosystem services (Norgaard, 2010) or, of course, coevolution. In all the cases listed above, the metaphor appears as a powerful medium for awareness of the issues affecting the relationship between environment and development, influenced by a worldview (or a model[5]) and generally leading to directives which are sometimes implicit. For example, Norgaard made a comment in 1995, in a short article published in the journal *Ecological Economics*, the article published in the journal *Science* the same year by a group of authors - economists and ecologists - on economic growth, the carrying capacity of ecosystems and the environment (Arrow *et al.*, 1995). The metaphor of carrying capacity, which is common usage in the field of environmental economics and ecological economics (the concept is even the basis of many works in bioeconomy) captures the attention of Norgaard. According to him, even if the conclusions reached by the authors of the article in *Science* are important (neither economic growth, nor the development of free trade internationally, is the antidote to the environmental crisis), they are still based on the design of mechanistic systems where the idea of limits is meaningful. *Conversely*, in a coevolutionary context, the idea of limits becomes meaningless. It is in this context that the interdisciplinary dialogue between economists and ecologists must find its foundations, as Norgaard argued at length in his book, *Development Betrayed*, published a year earlier. Norgaard thus writes (1995:130): "*The Science article is strong in that it conveys valuable ideas about biological diversity, ecosystem resilience, the possibilities of multiple environmental system equilibria, and the merits of adaptive environmental management. Nevertheless, the article is still couched in the language and hence processes of mechanical systems rather than, for example, coevolutionary systems. From a co-evolutionary perspective, there are no limits. Everything we do affects how things select on each other and thereby our co-evolution with numerous other species. The metaphor of limits says*

[4] It brings to mind as much the invisible hand of Adam Smith as the economic circuit developed by François Quesnay, likening it to the circulation of blood in the human body.

[5] According to Baumgärtner *et al.* (2008:389), "*A model is an abstract representation of a system under study, explicitly constructed for a certain purpose, and based on the concepts within a scientific community's basic construction of the world that are considered relevant for the purpose*".

*that if we* "*control*" *ourselves more and nature less, living within nature's bounds, we will have a greater chance of survival*". The vision of the world that Norgaard defends, one based on coevolution, does not mean that companies should participate in intensive exploitation of natural resources without responding. Thus, the idea of coevolutionary development takes a more political and normative turn, and it is worth taking time to understand the relationship between science and policy in the point of view put forth by Norgaard. However, as stressed by Kallis and Norgaard (2010: 697), "*coevolutionary studies are often vague on their policy premises, although they often yield concrete policy conclusions*".

The coevolutionary perspective can be a diagnostic tool to trace the historical evolution of the relationship between nature and societies - especially since the Industrial Revolution - and explicitly denouncing a world where the development of Western science and its influence on the relationship that societies have with nature would have led to a vision of Western development in which man remains the master and owner of nature. For example, the development of the use of pesticides in agriculture is a response to human needs, often without concern for the environmental and health impact that is created. Yet, as Norgaard regularly illustrated in his work, with a coevolutionary perspective, the struggle against insects and pests *through* the use of pesticides causes genetic mutations and adaptations to pesticides by insects and plants, which is the result of a complex set of interactions between the different dimensions of coevolution presented above. But the coevolution between social and environmental systems can also be mobilized as a normative framework, since we associate it with the idea of development. Norgaard (1984:529) thus recognises " [*t]he terms to coevolve*, *coevolution and coevolutionary are value free in this paper and merely refer to the reciprocal process of change. The term coevolutionary development is used to refer to coevolution that benefits man*". It is in this sense that Norgaard (1988) reinterprets the concept of sustainable development, from a coevolutionary perspective.

## 3. Robert Costanza and the concept of "ecosystem service"

Robert Costanza was born in 1950. After studying architecture and regional and urban planning, in 1974 Costanza began a Ph.D. program in Systems Ecology and Environmental Engineering - with a minor in Economics - at the University of Gainesville in Florida, under the direction of Howard Odum. He completed his dissertation in 1979. He then went on to do a postdoctorate at Louisiana State University in 1980-1981. The following year, he was appointed *assistant professor* in the department of marine sciences. In 1984, he became a professor in the biology department of the University of Maryland. In the wake of Howard T. Odum, Costanza would play a leading role in the structuring and activity planning of the Ecological Economics community - it is probably to him that we owe this term. He is one of the co-founders of the International Society for Ecological Economics (ISEE), and he was editor-in-chief of the journal *Ecological Economics* from 1989 to 2002. In 2002, he was appointed Professor of Ecological Economics at the University of Vermont. Since 2013, he has been a professor at the Crawford School of Public Policy at the Australian National University in Canberra.

Before looking at how the concept of “ecosystem service” emerged and was mobilized centrally by Costanza to characterize the process of ecological economics, we will return to his conception of ecology as an economy of nature.

### *3.1.From the economy of nature to ecological economics*

After defending his dissertation in 1979, Costanza was invited the next year by H. Daly to present his work at a symposium entitled “Energy, Economics, and the Environment”. Costanza [1980] takes up the idea expressed, among others, by H.T. Odum [1971] in the 1970s[6], a theory of energy value based on the amount of energy embedded in complex systems (the energy can be considered “as the monetary standard of ecology,” wrote E.P. Odum [1971:39]). He also shows, from a case study of the U.S. economy, that there is a strong correlation between the energy embodied in goods and services produced by different sectors of that economy and their monetary value expressed as gross national product. This is, as Costanza[7] emphasizes, a “theory of value production cost”, which explains the values of exchange. This approach captures what usually escapes the monetary measure of production, namely the energy used indirectly to produce goods (solar energy incorporated into agricultural products, for example) and work. It also allows us to calculate the value when there is no market or price - which is the case with most relationships with the environment. The backdrop of this research is the idea that energy - and, more broadly, nature - is a kind of “primary”

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[6] Costanza [1980] also refers to the work of L. von Boltzmann, F. Soddy, F. Cottrell, and B. Hannon. As I. Ropke [2004: 307] reminds us, Costanza met with the latter at the University of Illinois during his doctoral research to do the work of energy modelling of ecological and economic systems.

[7] Costanza [1980: 1224] wrote : “*An embodied energy theory of value thus makes sense and is empirically accurate only if the system boundaries are defined in an appropriate way. It is really a cost-of-production theory with all costs carried back to the solar energy necessary directly and indirectly to produce them”.*

production factor, on which the other production factors usually considered by economic theory depend[8]. Hence the idea of using energy indicators to reflect this interdependence. The aim of this article does not stop there. Indeed, his last paragraphs take a decidedly programmatic turn. Invoking the names of economists Boulding, Georgescu-Roegen, and Daly[9], Costanza then sketches a redefinition of the economy, noting that "the implications for a *new ecological economics* that links the natural and social sciences are great" [emphasis added]. Although the idea of limits of the biosphere may be clearly indicated - that is the meaning of the reference to Boulding's "*cowboy economy*" [1966], heralding what would soon be called "strong sustainability" -, this approach does not seek to challenge the approach of the standard economist, but rather to supplement it by giving it a biophysical foundation[10]. Starting with the idea that "*[t]he flow of energy is the primary concern of economics*", Costanza [1980:1224] calls for us to expand the boundaries of productive systems usually studied by economists; energy values allow us, according to him, to achieve an "internalization of externalities", particularly when there are no other indicators of value and no price signals. In this, Costanza only subscribes to the perspective developed by the Odum brothers, who defined ecology as a "*broad economy*" [Odum, 1976], including the cost of the works of nature and men.

In the 1980s, Costanza explores the prospect of a merger of monetary assessment and energy assessment, while continuing work in the field of energy efficiency [Cleveland *et al.*, 1984]. Thus, during the Wallenberg Symposium on the integration of economy and ecology, held in Stockholm in September 1982 - which is considered one of the first community structuring moments of Ecological Economics [Ropke, 2004: 308] -, Costanza [1984:9] presented a paper in which he stated that, according to him, the main issue in environmental management is finding a way to assign "shadow pricing" to natural resources. From his point of view, Ecological Economics - the term now appears in the title of his article - can offer a lot in this area by relating

[8] Costanza [1980:1219-1220] wrote : "[…] practically everything on the earth can be considered to be a direct or indirect product of past and present solar energy […] Fossil fuels and other natural resources represent millions of years of embodied sunlight. Environmental flows (such as winds, rain, and rivers) represent embodied sunlight of more recent origin. Humans, under this view, are the product of millions of years of solar-powered R&D and are maintained by an agriculture that uses both current sunlight and fossil sunlight. From this perspective, industrial capital is obviously created by the economic process and is not a net (or primary) input."

[9] Note that he is thanked at the end of the article for his help and comments.

[10] "*From the ecological perspective, markets can be viewed as an efficient energy allocation device that humans have developed to solve the common problem facing all species – survival*" [Costanza, 1980: 1224].

the economy that studies how resources are allocated within human societies to ecology, which studies how resources are allocated within nature. The task is to relate the two main ways of calculating shadow pricing: that of economists (monetary assessments, particularly through measures of willingness to pay) and that of ecologists (energy analysis). The first approach is based on the information that people have, which is far from perfect - despite efforts by environmental movements promoting awareness of the importance of the environment, which Costanza acknowledges[11]. Furthermore, contrary to the assumption generally followed by standard economists who see them as exogenous, individual preferences are likely to be handled by internal elements in the economic system (Costanza recalls the role of advertising, in particular). Therefore, pleads Costanza, the energy approach can help these individuals - and, more broadly, all decision-makers - to understand the importance of the environment for their well-being through the description and evaluation of a set of production relationships. Among the various avenues explored in modelling relationships between biophysical systems and economics, Costanza highlights his energy approach, because it is perfectly congruent with that of standard economists. In fact, according to Costanza (1984:12), if "*the markets were perfect*", if economic agents were perfectly informed, both types of evaluation, monetary and energy, would be equivalent. In that case, monetary sub-constraint maximization and sub-constraint maximization of the energy incorporated into goods would be identical. However, as a precaution, given the limitations faced by different valuation methods - not the least being data availability - Costanza [1984:17] recommends, at the end of his paper, using energy and monetary approaches together.

### 3.2. The goal of ecological economics: measuring the value of ecosystem services?

To support his claim empirically, Costanza [1984:12] uses in his argument a collaborative work with Christopher Neill from a few years earlier [Costanza & Neill, 1981] which led to the construction, on the level of the biosphere, of a matrix describing the necessary material and energy flows (9 processes) to produce a certain number of goods and services (9 *commodities*) to people and nature. This descriptive table of functional relationships between quantities of

[11] "*The willingness-to-pay approach to shadow pricing environmental resources is therefore effective to the extent of different levels of these resources on their own welfare. The approach of the environmental movement over the last decade has been to try to educate the population about the workings of the environment. To the extent that this has been effective, shadow pricing environmental resources via the willingness-to-pay approach can be successful*" [Costanza, 1984:10].

production factors used (solar and fossil energy) and quantities of goods and services produced for people and nature allows us to calculate a set of conversion keys between the amount of embodied energy and the monetary value of the outputs. The inspiration of economic methods in this reasoning and the construction of this general accounting is obvious: it appears close to the matrix of inter-industry trade developed by Leontieff in the 1940s to describe the United States' economy, which, as we know, then was taken as part of the national accounting. We also note in the text a reference to the *Production of goods from goods* from Sraffa - the difference here being that some production factors and some goods and services are not commodities, but fall within nature's economy. By clearly showing the dependence of the well-being of humanity on the biosphere, this matrix, wrote Costanza [1984:17], is a first step towards the establishment of an ecological economy. It allows, as suggested by Costanza and Neill [1981:751], policymakers to legitimately raise the question of the value of these goods and "ecosystem services"[12].

Over time, by continuing on this path of developing environmental accounting, Costanza would use this notion of "ecosystem service" more frankly to designate this economy of nature that he is committed to understanding. This is clear in "Valuation and management of wetland ecosystems", an article published by Costanza, Farber, and Maxwell [1989] in an early issue of *Ecological Economics*[13]. In accordance with Costanza's recommendation [1984] to use a variety of assessment methods, these authors compare the energy efficient approach and the monetary approach of a wetland located in Louisiana[14]. They obtain a range of values (from 2,500 to



[12] According to Costanza and Neill [1981:751] "*The potential utility to environmental managers and decision makers of defendable answers to questions like: what is the true extra-market value of rainfall? Or ecosystem services? Or nonrenewable resources? – is enormous*".

[13] "*Unfortunately, for the many ecosystem goods and services that humans do care about […]*", write Costanza *et al.* [1989:336].

[14] As regards the economic assessment, three benefits provided by the zone are identified: commercial fishing and professional hunting; the recreational value of the area; protection against storms. The methods used are taken from the survey of market prices of products sold commercially, the method of transport costs, and the contingent valuation. The energy assessment of the area is based on gross primary productivity of the ecosystem. The authors then estimate what it would cost the company to produce these quantities of energy (by converting fossil energy, which is estimated based on market price). Per acre, in 1983 dollars, with a discount rate of 3%, the monetary assessment is nearly 9,000 dollars, and the energy assessment is from 17,000 to 28,000 dollars. With a discount rate of 8%, the respective figures are 2,400 dollars and 6,400 to 10,000 dollars.

17,000 dollars/acre), which vary depending on the discount rate used; the authors emphasize that the most important changes in their assessments come from this variable... The energy assessment is at the high end of the evaluation, which meant to the authors that the contribution of the environment to the production and well-being of individuals was undervalued by traditional economic approaches. Costanza and his colleagues acknowledge that many uncertainties and flaws remain in their calculations, but their point of view is that it is preferable to have a bad assessment than no assessment at all...

This is the same pragmatic view that is defended in the famous article published by Costanza *et al.* (1997) in *Nature* on the assessment of ecosystem services on the planet. At the same time, we observe a shift: the methods chosen this time are those of standard environmental economics: they relate primarily to the assessment of the willingness of individuals to pay - but there is also reference to land prices, for coastal ecosystems... Still, energy assessments have not completely disappeared from the exercise - a Costanza article *et al.* [1989] is cited in the bibliography. After having clarified that they were used to making comparisons with the results obtained through monetary assessments, Costanza *et al.* (1997: 258) conclude: "*Interestingly, different methods showed fairly close agreement in the final results*".

Although Costanza has not given up the idea of complementarity between monetary and energy approaches - this is evident in the methodological discussion led by him and his colleagues in the introductory article to a special issue of *Ecological Economics* devoted to the value of ecosystem services (Farber *et al*, 2002), which refer to Ricardo and Sraffa[15] -, the *Nature* article is symptomatic of a two-fold evolution that has been observed, especially in the columns in the journal *Ecological Economics*: first, an increasingly strong focus is placed on ecosystem services - in the name of profound knowledge of natural capital - and, second, an increasingly pronounced appeal for a monetary evaluation of it.

## Conclusion

Twenty-five years after the formal establishment of the ISEE, the field of ecological economics has become huge. The books and articles that deal with this framework now number in the tens of thousands. Covering such a field requires the use of specific bibliometric methods. Without denying the interest of these approaches, one must be aware of their limitations: what is gained through the amount of material they can process is sometimes lost because of

[15] "*Available energy is thus the only 'basic' commodity and is ultimately the only 'scarce' factor of production, thereby satisfying the criteria for a production-based theory that can explain exchange values*" [Farber *et al.*, 2002: 382].

the lack of precision analysing the content of these writings. We therefore advocate complementary approaches that are established in the field of history of thought, such as, for example, conceptual history and history of research paths. In this first work, which is still largely exploratory, we sought to examine the intersection of these two approaches by studying how the research path of two eminent personalities in the field of Ecological Economics - Richard Norgaard and Robert Costanza - became involved in two innovative concepts of Ecological Economics - the concepts of co-evolution and ecosystem service.

A first reading is, as we have pointed out in the introduction, to note the existing symmetry between the first researcher, an economist who was inspired by a concept embraced by ecologists, and the second, an ecologist who has always displayed a strong will to adopt the reasoning of economists. This perfectly illustrates the general philosophy of the Ecological Economics project, which, from the beginning, has aimed to merge these two major scientific communities in order to create new knowledge, particularly through evolving concepts. A second reading deals with the analysis of theoretical proposals made by these two authors: on the one hand, a perspective of allocation and optimization which follows the logic of standard economics, an extended economy, embracing natural and human systems, which was built by Costanza from the development of a theory of value, from the description of a set of transactions and the calculation of a set of shadow prices. In this context, the ecosystem is seen as "natural capital", providing goods and services on which the well-being of human societies depends. The methodological pluralism (sometimes using a calculation method, sometimes another) is then used to provide a unified vision of the relationship between people and the biosphere on a broader basis. On the other hand, from two non-unified scientific fields, ecological economics appears rather as a field of questions. This is another vision of the ecosystem that we encounter (which is also found in Costanza in writings other than the ones we have seen here) as an evolutionary, complex system in constant interaction with social systems - which leads us to reconsider the very idea of development. Questioning the established metrics and adopted conventions, the methodological pluralism defended by Norgaard, which brings us to the threshold of institutionalist thought, conflicts with that of Costanza. A third reading brings us to the thorny question of limits, which one can consider fundamental in the organization of the area separating ecological economics from the standard economic approach: while they are clearly indicated by Costanza - natural capital is not entirely substitutable -, they become increasingly blurred in Norgaard.

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